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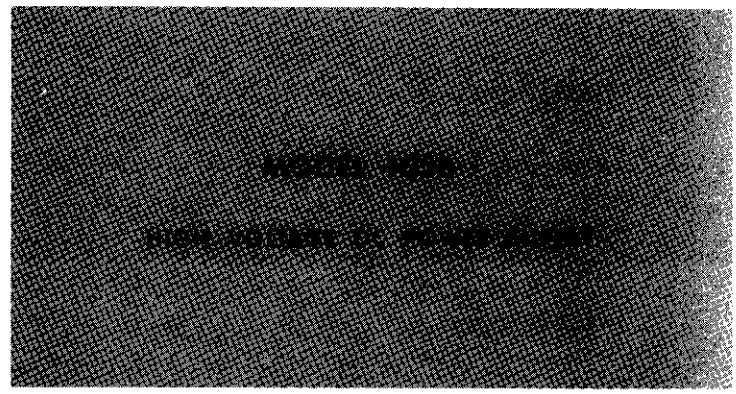

405B serial no. 123 and above.

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Model 405B High Voltage DC Power Supply

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. GENERAL DESCRIPTION

1-3. The Fluke Model 405B is a High Voltage DC Power Supply having the capability of providing an output of 0 to 3100 VDC, and 0 to 30 milliamperes. The power supply reference voltage is obtained from a temperature compensated gas reference tube. The reference tube and its associated constant current source are protected from rapid changes in ambient temperature by a plastic thermal shield. The constant current source also provides temperature compensation for the reference tube.

1-4. The Model 405B is a hybrid supply, utilizing the best features of both vacuum tubes and transistors. The use of transistors in the low signal level portions of the instrument eliminates the requirement for a regulated filament supply. The instrument has excellent isolation of the output from variations of either line voltage or load current. Either the + or - output terminal may be grounded. A time-delay relay is incorporated in the input circuitry, which prolongs the life of the high voltage vacuum tubes.

1-5. The power transformer is provided with a dual primary for operation from either 115 or 230 volts. The secondary of the power transformer has taps which are switched according to the selected output voltage. This reduces the amount of power dissipated by the series passing tubes at low output voltages. The 405B is equipped with an over-current relay, which protects both the instrument and the load to which it is connected.

1-6. Precision wirewound resistors are used in all voltage sampling applications, and at other critical places in the circuit. This permits the use of calibrated output voltage controls and ensures excellent long term stability.

1-7. RECEIVING INSPECTION

This instrument has been thoroughly checked and tested before being shipped from the factory. Immediately after receiving the instrument, carefully inspect for damage which may have occurred in transit. If any damage is noted, follow the instructions outlined on the warranty page in the back of this manual.

1-8. SPECIFICATIONS

1-9. ELECTRICAL

OUTPUT VOLTAGE: 0 to ±3100 VDC

OUTPUT CURRENT: 0 to 30 milliamperes

OUTPUT POLARITY: + or - grounded by front panel switch.

LINE REGULATION: 0.001% or 5 mv (whichever is is greater) for a 10% line change from nominal.

LOAD REGULATION: 0.001% or 5 mv (whichever is greater) for full load change.

STABILITY: ±0.005% per hour; ±0.03% per day after warmup.

RESOLUTION: 5 millivolts, maximum.

RIPPLE: Less than 1 mv RMS; less than 5 mv peak-to peak.

VOLTAGE CALIBRATION:
Five 500 volt increments
Five 100 volt increments
Nine 10 volt increments
Nine 1 volt increments
One 0 to 1.2 volt vernier

CALIBRATION ACCURACY: ±0.25% or 250 mv.

OVER CURRENT PROTECTION: Set to latch off at 35 ma load current.

METER: 3100-0-3100 volts.

TEMPERATURE COEFFICIENT OF OUTPUT: Less than 20 ppm per °C from +10°C to +40°C.

INPUT POWER: 115/230 VAC ±10%, 50-440 cycles, approximately 300 VA at full load.

1-10. MECHANICAL

OUTPUT CONNECTIONS: One MS3102A-18-16S front and rear (one mating connector supplied).

HUMIDITY: 0 to 80%.

OPERATING TEMPERATURE: 0°C to +50°C.

STORAGE TEMPERATURE: -20°C to +70°C.

ALTITUDE, OPERATING: 10,000 ft.

ALTITUDE, NON-OPERATING: 50,000 ft.

VIBRATION: MIL-T-945A.

SHOCK: MIL-E-4970A (20 g's, 11 milliseconds).

SIZE: 19" wide by 5-1/4" high by 18" deep. (Rack mount with rubber supports for bench use).

WEIGHT: Approximately 32 pounds.

SECTION II

OPERATING INSTRUCTIONS

2-1. FUNCTION OF EXTERNAL CONTROLS, TERMINALS, AND INDICATORS

2-2. The location, reference designation, and functional description of external controls, terminals, and indicators on the Model 405B are given in Figure 2-1.

CONTROL	LOCATION	REFERENCE DESIGNATION	FUNCTIONAL DESCRIPTION
POWER switch	Front panel	S1	Applies AC line power to the control circuitry and to the primary of the transformer.
POWER indicator lamp	Front panel	DS1	Illuminates when power is applied to the control circuitry.
HIGH-VOLTAGE switch	Front panel	S2	Applies transformer power to the high-voltage rectifiers.
STANDBY-RESET lamp	Front panel	DS2	Illuminates when the power supply is operating in the standby condition, i.e., HIGH VOLTAGE switch set to STANDBY-RESET.
HV ON lamp	Front panel	DS3	Illuminates when power is applied to the high voltage rectifiers.
POLARITY switch	Front panel	S9	Used to select positive or negative output relative to chassis ground.
DC voltage dials	Front panel	S5, S6, S7, S8, and R319	The first four controls select the output voltage in increments of 500 volts, 100 volts, 10 volts, and 1 volt, respectively. R319 provides a continuous output range of 0 to 1.2 volts.
Voltmeter	Front panel	M1	Indicates the approximate output voltage. Accuracy is ±3% of full scale.
Output connectors	Front and back panels	J1 and J2	Provided for connecting the load to the instrument. One mating connector is supplied.

Figure 2-1. FUNCTION OF EXTERNAL CONTROLS, TERMINALS, AND INDICATORS

2-3. INITIAL OPERATION

2-4. The 405B may be used on either 115 volts, or 230 volts, at a frequency from 50 to 440 cycles. The instrument is usually shipped for use on 115 volts. If it becomes desireable to change from one voltage to the other, remove the top cover of the power supply and change the jumper wires and fuse as shown on the transformer decal.

2-5. The following procedure is recommended when operating the Model 405B for the first time after shipping or a long period of idleness. This procedure will minimize the possiblity of damage resulting from a faulty component.

a. Connect line plug to a 115 volt AC source. If the instrument has been wired for 230 VAC, connect to 230 VAC.

WARNING

This instrument is equipped with a 3-wire line cord, one lead of which is connected to the metal chassis. Connection to a properly wired outlet automatically connects the chassis of the instrument to earth ground. If the adapter furnished with the instrument is used to connect to a two-contact outlet, the green lead extending from the adapter should be connected to a suitable ground.

b. Set HIGH VOLTAGE switch to the STANDBY-RESET position.

c. Set POWER switch to ON. The POWER lamp will illuminate. After approximately 30 seconds, the time-delay relay will close and the STANDBY-RESET lamp will illuminate.

d. Set second voltage dial to 500.

e. After STANDBY-RESET lamp illuminates, set HIGH VOLTAGE switch to HV ON. Carefully observe if HV ON lamp illuminates and if the output voltage rises to within 3% of 500 volts as indicated by the panel meter.

CAUTION

If the output exceeds 500 volts, immediately set the HIGH VOLTAGE switch to STANDBY-RESET.

f. If the output voltage is 500 volts, the power supply may be operated as in paragraph 2-6. If the output is not 500 volts, perform steps g. through i.

g. Set HIGH VOLTAGE switch to STANDBY-RESET.

h. Locate and correct source of trouble. Refer to paragraph 4-5.

i. Repeat initial operation.

2-6. OPERATING PROCEDURE

a. Set the POWER switch to ON. The POWER lamp will illuminate.

b. Set HIGH VOLTAGE switch to STANDBY-RESET. After approximately 30 seconds, the time-delay relay will close and the STANDBY-RESET lamp will illuminate.

c. Set POLARITY switch to desired polarity.

d. Set voltage dials to the desired output voltage.

e. Connect the load circuit securely to the power supply.

f. Set the HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate.

g. The overall accuracy of the meter in the 405B, including multiplying and shunting resistors, is approximately 3% of full scale. However, the accuracy of the 405B is 0.25% of the selected output voltage. For example, if a voltage of 1000 volts is selected, the meter will indicate from 907 volts to 1,093 volts (±3% of 3100 = ±93). However, the actual output voltage will be between 997.5 volts and 1002.5 volts (±0.25% of 1000 = ±2.5). Thus, the voltage indicated by the voltage control dials is approximately 12 times as accurate as the meter indication at full scale and proportionally more accurate at less than full scale.

h. Always set the HIGH VOLTAGE switch to STANDBY-RESET and wait until the output voltage decays to zero before connecting a load to, or disconnecting a load from the output connector.

i. The output polarity of the 405B may be changed at any time when no load is connected to the instrument. When an external load is connected, especially one that is highly capacitive, the HIGH VOLTAGE control should be set to STANDBY-RESET, or the output voltage should be reduced to 500 volts, before changing the polarity. If continual polarity switching is done at high voltages, the polarity switch may be damaged.

j. Occasionally the overload circuit may remove power from the output connectors. When this occurs, the HV ON lamp will extinguish. The output voltage may be re-applied to the output connectors as follows:

(1) Set the HIGH VOLTAGE switch to the STANDBY-RESET position. After approximately 30 seconds, the STANDBY-RESET lamp will illuminate.

(2) Set the HIGH VOLTAGE switch to the HV ON position. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate. The output voltage will appear at the output connectors.

2-7. CALIBRATION OF METERS

2-8. The 405B may be used for direct calibration of DC instruments to an accuracy of 0.25% or 250 mv at 3100 cardinal points, 1 volt apart, from 0 to 3099 volts. The vernier dial provides an additional 1.2 volts of range for calibration between cardinal points. Proceed as follows:

a. Set POWER switch to ON. The POWER lamp will illuminate.

b. Set HIGH VOLTAGE switch to STANDBY-RESET. After approximately 30 seconds, the time-delay relay will close and the STANDBY-RESET lamp will illuminate.

c. Set POLARITY switch to desired polarity.

d. Connect instrument being calibrated firmly to power supply. Check external circuit for conflicts in grounding before applying power to the load.

e. Set HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate.

f. Set first four voltage dials to the desired cardinal points. Use the last dial if a calibration point between one of the cardinal points is desired.

g. Always set the HIGH VOLTAGE switch to STANDBY-RESET and wait until the output voltage decays to zero before connecting a load to, or disconnecting a load from the output connector.

2-9. When used with a Fluke differential voltmeter and voltage divider, the 405B is capable of calibrating DC instruments from 0 to 3100 volts within an accuracy of 0.01% to 0.06% with 5 millivolts resolution. For calibration of instruments from 0 to 500 volts, proceed as follows:

a. Set POWER switch to ON. The POWER lamp will illuminate.

b. Set the HIGH VOLTAGE switch to STANDBY-RESET. After approximately 30 seconds, the time-delay relay will close and the STANDBY-RESET lamp will illuminate.

c. Set the POLARITY switch to the desired polarity.

d. Connect the instrument being calibrated firmly to the power supply. Check the external circuit for conflicts in grounding before applying power to the load.

e. Connect a Fluke differential voltmeter to the instrument being calibrated.

f. Set the HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate.

g. Set differential voltmeter to measure the voltage desired at the calibration point.

h. Null the differential voltmeter by adjusting the power supply voltage dials. The accuracy of the voltage measured is from 0.01% to 0.05%, according to the accuracy of the differential voltmeter used.

i. Set HIGH VOLTAGE switch to STANDBY-RESET.

j. Repeat steps g. through i. for as many calibration points as desired.

2-10. For calibration of instruments from 500 volts to 3100 volts, proceed as follows:

a. Set POWER switch to ON. The POWER lamp will illuminate.

b. Set the HIGH VOLTAGE switch to STANDBY-RESET. After approximately 30 seconds, the time-delay relay will close and the STANDBY-RESET lamp will illuminate.

c. Set the POLARITY switch to the desired polarity.

d. Connect the instrument being calibrated firmly to the power supply. Check the external circuit for conflicts in grounding before applying power to the load.

e. Connect a Fluke Model 80B Voltage Divider to the instrument being calibrated, and then connect a differential voltmeter to the 500 volt-maximum divider output terminals.

f. Set the HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate.

g. Set the differential voltmeter to measure the voltage at the desired calibration point, considering the voltage division ratio of the voltage divider.

h. Null the differential voltmeter by adjusting the power supply voltage dials. The accuracy of the voltage measured is from 0.02% to 0.06%, according to the accuracy of the differential voltmeter and voltage divider used.

i. Set the HIGH VOLTAGE switch to STANDBY-RESET.

j. Repeat steps g. through i. for as many calibration points as desired.

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. This section of the manual describes the operation of the Model 405B. Reference is made to the functional schematic following Section V. This schematic is intended to aid in understanding the theory of operation, and in troubleshooting. A block diagram of the 405B is given in Figure 3-1. Operation of the 405B is described in the following paragraphs.

3-3. CIRCUIT DESCRIPTIONS

3-4. A half-wave rectifier is formed by CR201, R201, R202, and C203, which furnishes DC voltage to the control relays K1, K201, and K202. Approximately 30 seconds after power is applied to the instrument, time-delay relay K201 closes, if S2 is set to the STAND-BY-RESET position. This energizes K202, which opens K202A, removing K201 from the circuit, and closing K202B and K202C. When switch S2 is set to the HV ON position, relay K1 is energized, which closes K1A, and applies transformer voltage to CR1 and CR2.

3-5. Relay K203 provides overcurrent protection. If the output current exceeds approximately 35 milli-amperes, K203 is actuated, which closes K203A. This de-energizes K202, which closes K202A, and opens K202B and K202C, and extinguishes the HV ON lamp. Relay K1 is thus de-energized, and high voltage is removed from the output terminals. Before high-voltage can be re-applied to the output terminals, switch S2 must be set to the STANDBY-RESET position. After the time-delay cycle is complete, voltage can be applied to the output connector by setting switch S2 to the HV ON position.

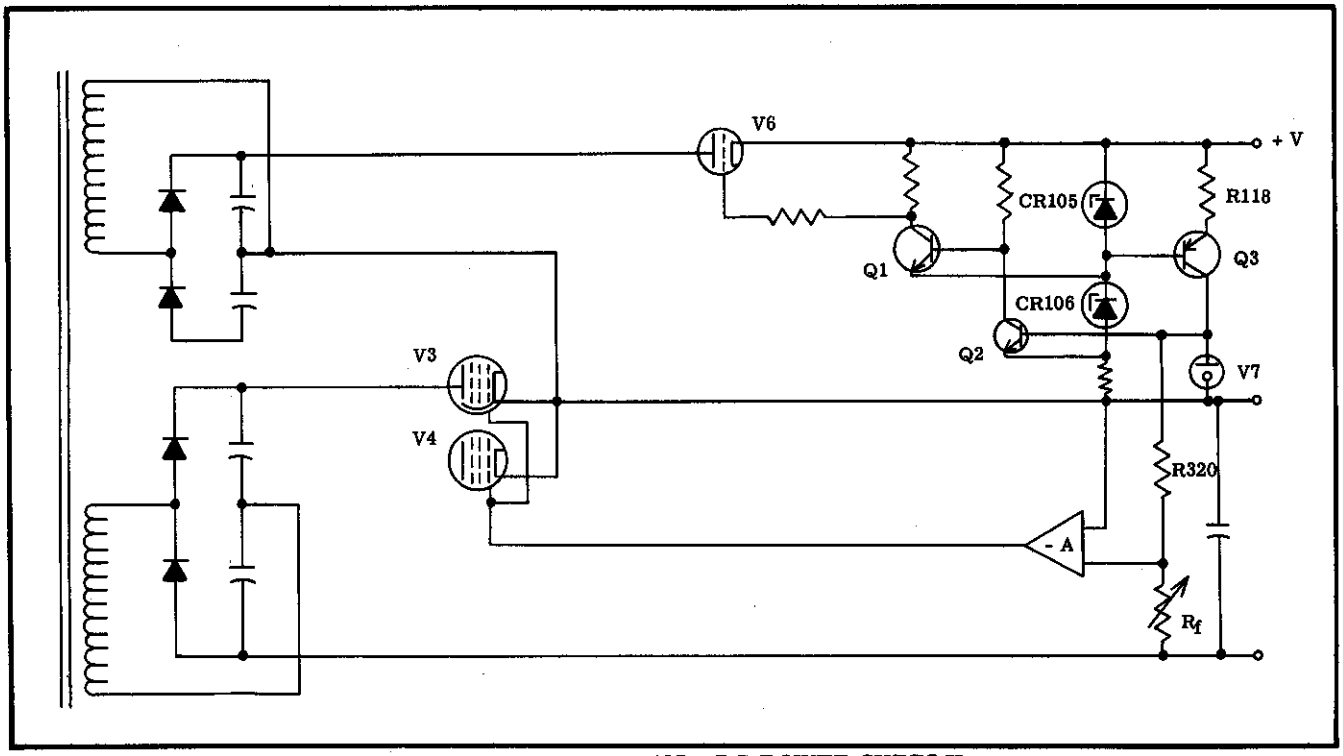


Figure 3-1. MODEL 405B DC POWER SUPPLY

3-6. The main output voltage is developed by CR1, CR2, C204 through C215, and R205 through R216. This is a full-wave, voltage-doubler circuit, which applies rectified, filtered, DC voltage to the plates of V3 and V4. The taps on the high voltage transformer winding Provide approximate control of the unregulated DC voltage, which minimizes power dissipation in V3 and V4 at low output voltage.

3-7. The main differential amplifier (Q5 and Q6) controls the output voltage. As shown in the schematic diagram, one input of the differential amplifier is connected to the positive bus. The other input is connected at the junction of resistor R320, and the voltage control resistors R301 through R319. (See Figure 3-1.) The tendency of the differential amplifier is to maintain the same voltage at both of its input terminals, which is positive bus potential. Since V7 maintains a constant voltage of 85 volts, the current through R320 is constant at 2 milliamperes, and consequently, the current through the voltage control resistors is also 2 milliamperes. Thus the output voltage is equal to 2 milliamperes multiplied by the resistance of the voltage control resistors; and the control ratio is 500 ohms per volt.

3-8. The output from the differential amplifier, which is proportional to the difference between the two inputs, is applied to the base of amplifier Q4. Assume the output voltage rises above the selected value. The output from Q5 becomes negative, which causes Q4 to conduct less. The input into the grid of V5 becomes more positive, which causes V5 to conduct more. This lowers the potential of the grids of V3 and V4, which causes V3 and V4 to conduct less, and thus reduces the output voltage to the original value.

3-9. DC voltage for both the positive and negative auxiliary supplies is obtained from one transformer winding. One terminal of this winding is connected to the positive output of the 405B, which is the zero volt reference bus. The other terminal of the winding is connected to the junction of two half-wave rectifiers and filters. A positive auxiliary voltage of +390 volts is obtained from CR101, CR102, C102, R103, and R104. A negative auxiliary voltage of -390 volts is obtained from CR103, CR104, C103, R105, and R106.

3-10. DC voltage for the +105 volt No. 1 supply is obtained by means of R107 in series with V1. This arrangement provides a shunt regulated screen voltage source for V3 and V4, and also limits the maximum screen current conducted by V3 and V4. The -150 volt supply is obtained from R108 and V2, similiar to the +105 volt No. 1 supply.

3-11. The +390 volts is applied to the plates of V6, which is controlled by a two-stage amplifier, Q1 and Q2. A regulated +105 volts is obtained from the cathodes of V6. The reference voltage is applied to the base of Q2. The +105 volts is sampled by the divider string consisting of CR105, CR106, R115, and R116, and this sample is applied to the emitter of Q2. Assume the +105 volts rises. This tends to reverse-bias the emitter junction of Q2, thus decreasing its conduction. This causes Q1 to tend to conduct more, which lowers the potential on the grids of V6, causing V6 to conduct less, thus reducing the regulated voltage to the correct value.

3-12. The constant current source for the voltage reference tube is Q3. The base of Q3 is connected between two zener diodes CR105 and CR106, which provides a stable bias voltage for Q3. Thermistor R120 provides temperature compensation for Q3.

3-13. ACCURACY

3-14. The main sampling string resistors in the 405B are accurate to within ±0.1%. However, the accuracy of the 405B is specified as ±0.25%, because the calibration accuracy is also dependent upon the stability of the reference voltage. The voltage of reference tube V7 (OG3) changes slightly due to aging. The accuracy of the supply will remain within ±0.25% for approximately 30 days. The calibration accuracy may be maintained at better than ±0.25% if the reference supply is recalibrated more often than the usual calibration period of 30 days.

3-15. All calibrated power supplies have an accuracy limit (floor) as the output voltage approaches zero. This floor is caused by zero shift in the error amplifier, contact resistance in the sampling string circuit, and the accuracy of the sampling string resistors used for the least significant digits. The accuracy floor may be reduced by using more expensive components and additional circuitry. However, this results in greater initial cost and longer calibration time. Thus, very low accuracy floors are usually found only in precision calibrators. The 405B has an accuracy of ±0.25% or 250 millivolts, whichever is greater, when all five voltage dials are used. Thus, the ±0.25% accuracy applies from 3100 volts to 100 volts. If it is desired to use only the first three voltage dials, the accuracy is ±0.25% or 100 millivolts. Thus the ±0.25% accuracy is extended down to 40 volts.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. Maintenance of the Model 405B DC Power Supply should consist primarily of occasional cleaning, tube replacement, and calibration. Preventive maintenance is discussed in paragraph 4-4. A discussion of troubleshooting and a troubleshooting chart are presented in paragraphs 4-5 thru 4-8. Calibration procedures and the equipment necessary are presented in paragraphs 4-9 thru 4-13.

4-3. PREVENTIVE MAINTENANCE

NOTE

It should be apparent that caution should be exercised when servicing this power supply. The metal shell of some of the electrolytic capacitors may be as much as 4500 volts above chassis ground. Capacitors C115 and C116 are high-quality, plastic-dielectric units capable of retaining a charge for several days. Before servicing or removing tubes, all capacitors and plate caps should be shorted to the chassis. It is recommended that the shorting wire remain connected to C115 and C116 during servicing, to prevent build-up of capacitor voltage due to dielectric polarization.

4-4. Periodic cleaning of the Model 405B is desirable because of the high-voltage present. Any contamination, particularly on the high voltage capacitors, may cause corona discharge, which will appear as noise in the output voltage. Components may be cleaned with a lint-free rag saturated with Metriclene solvent, M4 (Manufactured by the John B. Moore Corp., Nutley, New Jersey). This is a high-grade, non-toxic, methyl ethyl ketone solvent. The ceramic switches may be cleaned using a brush and Metriclene. After cleaning, the ceramic surface should be coated with a 10% solution of Dow Corning silicon fluid (200 viscosity grade). Metriclene, M4, may be used as a thinner for the silicon fluid.

4-5. TROUBLESHOOTING

4-6. It is recommended that all checks be made with the POLARITY switch turned to the negative output polarity, and when possible, output voltage turned to 500 volts. Most voltages are refered to the positive bus, and when the output polarity is negative, this positive bus is connected to the earth grounded chassis. This affords some protection to the person performing the tests.

4-7. The power supply should be allowed to warm-up before troubleshooting. Usually, one-half hour of operation is adequate. Figure 4-1 is a list of various failures and probable causes. Reference to Figure 4-1 will occasionally indicate the cause of a failure. Components may be located by referring to Section V.

SYMPTOM	PROBABLE CAUSE	REMEDY
No output.	Blown fuse.	Check fuse F1, and replace if necessary.
	Open heater of V3 or V4.	Determine if tube will warm-up; if not, replace.
	Open R140; shorted C115.	Check and replace if necessary.
Constant percentage error in output voltage.	Out of calibration.	Recalibrate per paragraphs 4-9 thru 4-13.
	Defective R320.	Check and replace if necessary.

Figure 4-1. TROUBLESHOOTING (sheet 1 of 2)

SYMPTOM	PROBABLE CAUSE	REMEDY
Percentage error over part of range.	Defective wirewound resistor in the sampling string. (R301 thru R319)	Set output voltage to maximum and decrease one position at a time until error disappears. The defective resistor will be found at the last switch position in which the error was noted.
Output erratic over part of range.	Same as percentage error over part of range.	
Output erratic over entire range.	Defective V3 or V4. Defective voltage selector switch, or dirty switch printed-circuit-board. Defective R140 or R320.	Check by replacement. Replace switch, clean printed-circuit-board. Check and replace if necessary.
Output rises to over 3KV and follows line voltage variations.	Defective V3, V4, V5, Q4, Q5, or Q6. Open sample resistor or switch.	Test and replace if necessary. Test and replace if necessary.
Poor load regulation.	Defective Q4, Q5, Q6 or V5.	Check by replacement.
Output voltage suddenly rises above preset valve.	Internal arcing in V3 and V4.	Check by replacement.
Noise in output.	Dirty high-voltage switches, capacitors, or switch printed circuit board.	Clean per paragraph 4-4.
Excessive drift.	Defective V7, Q5 or Q6.	Check by replacement. Refer to paragraph 4-8. d.
Excessive Ripple.	Excessive ripple in +105V, auxiliary supply. Defective C115, C116, Q5, or Q6.	If auxiliary supply ripple exceeds approximately 5 mv, replace defective component. Check and replace if necessary.
Loss of control.	Open R139.	Check and replace if necessary.

Figure 4-1. TROUBLESHOOTING (sheet 2 of 2)

EQUIPMENT	SPECIFICATIONS REQUIRED
Variable transformer	3 ampere capacity, 100 volts to 130 volts.
RMS Voltmeter, Fluke 910A or equiv.	Measurement of non-sinusoidal waves.
DC Differential Voltmeter, Fluke 801B or equiv.	Voltmeter-Voltage Divider combination must be capable of measuring 3000 VDC, with a minimum accuracy of 0.05% + 50 uv.
DC Voltage Divider, Fluke 80B-3 or equiv.	
Oscilloscope, Tektronics Model 541 with Type "L" plug-in unit, or equiv.	Minimum sensitivity of 5 mv/cm.
Blocking capacitor	0.05 micro-farads, 5000 VDC rating.
Load Resistor	16.67K, 0.03%, 16 Watts minimum power dissipation.
Load Resistor	100K, 3%, 90 Watts minimum power dissipation, available from Ward Leonard or Ohmite.

Figure 4-2. TROUBLESHOOTING EQUIPMENT

4-8. The following paragraphs are specific tests which can be performed on the 405B to facilitate troubleshooting and/or performance testing. A list of equipment required for troubleshooting is given in Figure 4-2.

a. Screen Supply Voltage Test

(1) Connect the negative 801B lead to 405B chassis ground (shell of output connector).

(2) Connect the positive 801B lead to the junction of R107 and V1.

(3) Set the POWER switch to ON.

(4) Set the POLARITY switch to negative.

(5) Set the HIGH VOLTAGE switch to ON.

(6) The 801B should indicate 107 (±3) volts.

b. +105 Volt Auxiliary Supply Voltage Test

(1) Connect the positive lead of the 801B to pin 3 of V6.

(2) Connect the negative lead of the 801B to chassis ground.

(3) Set the POWER switch to ON.

(4) Set the POLARITY switch to negative.

(5) Set the HIGH VOLTAGE switch to ON.

(6) The 801B should indicate 104 (±4) volts.

c. -150 Volt Auxiliary Supply Voltage Test

(1) Connect the positive lead of the 801B to pin 2 of V2.

(2) Connect the common lead of the 801B to chassis ground.

(3) Set the POWER switch to ON.

(4) Set the POLARITY switch to negative.

(5) Set the HIGH VOLTAGE switch to ON.

(6) The 801B should indicate -150 (±5) volts.

d. Reference Voltage Test

(1) Connect the positive 801B lead to pin 1 of V7.

(2) Connect the common lead of the 801B to chassis ground.

(3) Set the POWER switch to ON.

(4) Set the POLARITY switch to negative.

(5) Set the HIGH VOLTAGE switch to ON.

(6) Record the voltage indicated by the 801B.

(7) If the voltage measured in step (6) is 81 volts to 83 volts, verify that there is a jumper installed between R320 and R321. (Refer to the schematic diagram). If the voltage measured in step (6) is 83 volts to 85 volts, verify that there is a jumper installed between R320 and R322. If the voltage measured in step (6) is 85 volts to 87 volts, verify that neither of the above jumpers is installed.

(8) Ocassionally, the reference tube V7 must be replaced. After the new tube is aged at least 48 hours, verify that the connection within the instrument is correct for the voltage of the new tube by performing steps (1) through (7) above. The instrument should also be recalibrated when V7 is replaced.

e. Output at Zero Volts

(1) Set the front panel decade controls to zero.

(2) Connect the 801B across the output connector.

(3) The 801B should indicate less than 0.25 volts in both output polarities. If not, exchange Q5 or Q6 with Q1, Q2, Q4, or replace if necessary. For minimum error at zero output, the beta of Q5 and Q6 must be matched to within 10%.

f. Line Regulation

(1) Connect the variable transformer between the 405B and the line. Set the transformer to 115 volts output.

(2) Set the second decade control to 500 volts.

(3) Connect the 801B across the output connector and record the output voltage.
(4) Increase the variable transformer output to 130 volts. The 801B should indicate less than 0.005 volts change from the voltage measured in step (3).
(5) Decrease the variable transformer output to 100 volts. The 801B should indicate less than 0.005 volts change from the voltage measured in step (3).
(6) Set the POWER switch to off.
(7) Disconnect the 801B. Connect the voltage divider to the 405B, and connect the 801B to the output of the voltage divider.
(8) Set the POWER switch to ON.
(9) Set the decade controls to 3000 volts.
(10) Set the variable transformer output to 115 volts. Record the 405B output voltage measured by the voltmeter-voltage divider combination.
(11) Increase the variable transformer output to 130 volts. The voltmeter-voltage divider combination should indicate less than 0.030 volts change in the 405B output voltage measured in step (10). For example, if using the Fluke Model 80B-3 Voltage Divider, the 801B should indicate less than 0.005 volts change.
(12) Decrease the variable transformer output to 100 volts. The voltmeter-voltage divider combination should indicate less than 0.030 volts change from the output voltage measured in step (10). For example, if the Fluke Model 80B-3 Voltage Divider is being used, the 801B should indicate less than 0.005 volts change.

g. Load Regulation

(1) Connect the variable transformer between the 405B and the line. Set the transformer to 100 volts output.
(2) Set the POWER switch to ON.
(3) Set the decade controls to 500 volts.
(4) Connect the 801B to the output connector. Record the voltage indicated by the 801B.
(5) Connect the 16.67K load resistor to the 405B. The load current should be 0.030 (±0.001) amperes.
(6) The 801B should indicate less than 0.005 volts difference from the voltage measured in step (4).
(7) Set the POWER switch to off.
(8) Disconnect the 801B and the load from the 405B.
(9) Connect the voltage divider to the output connector, and connect the 801B to the output of the voltage divider.
(10) Set the POWER switch to on.
(11) Set the decade controls to 3000 volts.
(12) Record the 405B output voltage measured by the voltmeter-voltage divider combination.
(13) Carefully connect the 100K load resistor to the 405B. The load current should be 0.030 (±0.001) amperes.
(14) The voltmeter-voltage divider combination should indicate less than 0.030 volts change from the 405B output voltage measured in step (12). For example, if the Fluke Model 80B-3 Voltage Divider is being used, the 801B should indicate less than 0.005 volts change.

h. Ripple

(1) Connect the variable transformer between the 405B and the line.
(2) Connect the 910A RMS voltmeter across the same output connector.
(3) Connect the oscilloscope across the output connector.
(4) Set the decade controls to 500 volts.
(5) Vary the transformer output from 100 volts to 130 volts. The 910A should indicate less than 0.001 volt RMS ripple, and the oscilloscope should indicate less than 0.005 volt peak-to-peak ripple.
(6) Set the decade controls to zero.
(7) Disconnevt the 910A from the output connector of the 405B.
(8) Connect the 0.005 uf, 5000 volt capacitor in series with the 910A input terminals, and connect the combination across the 405 B output.
(9) Set the decade controls to 3000 volts.
(10) Vary the transformer output voltage from 100 volts to 130 volts. The 910A should indicate less than 0.001 volt RMS ripple, and the oscilloscope should indicate less than 0.005 volt peak-to-peak ripple.

4-9. CALIBRATION

4-10. The Model 405B may be calibrated as often as necessary. However, it is recommended that the reference voltage be checked every 30 days, and the overcurrent limit be checked every six months. As reference tube V7 (OG3) ages, the reference voltage changes slightly. It has been found that some reference tubes are more stable than others. However, most reference tubes will change by less than 0.1% for every 100 hours of operation after the first hundred hours. If the output voltage is recorded before the reference current is adjusted, a more realistic calibration period can be determined.

4-11. The equipment required for calibration is given in Figure 4-3.

EQUIPMENT	REQUIRED SPECIFICATIONS
DC Differential Voltmeter, Fluke Model 801B, or equiv.	Voltmeter-Voltage Divider combination must be capable measuring 0 to 3000 volts with a minimum accuracy of 0.05% + 50 uv.
DC Voltage Divider, Fluke Model 80B-3, or equiv.	
Load resistor	1K, 5%, 2W
Insulated Screwdriver	

Figure 4-3. EQUIPMENT REQUIRED FOR CALIBRATION

4-12. ADJUSTMENT OF REFERENCE CURRENT

a. Connect the voltage divider to the output of the 405B, and connect the differential voltmeter to the output of the voltage divider.

b. Set the controls on the 405B as follows:

first voltage dial	2500
second voltage dial	500
remaining voltage dials	0
POLARITY switch	- (negative)
HIGH VOLTAGE switch	STANDBY-RESET
POWER switch	ON

c. After the STANDBY-RESET lamp illuminates, set the HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish and the HV ON lamp will illuminate.

d. Set differential voltmeter to measure 3000 volts including the voltage divider ratio. For example, using the Fluke Model 80B-3 Voltage Divider, set the differential voltmeter to measure 500 volts; or, if using the Model 80B-5 Voltage Divider, set the differential voltmeter to measure 300 volts.

WARNING

Use an insulated screwdriver to adjust R140. The case of this resistor is 85 volts above chassis ground for negative output polarity, and may be as much as 3185 volts above ground in positive output polarity.

e. Adjust R140 for a null on the differential voltmeter. Within 2 volts of 3000 volts is sufficient (333 mv with 80B-3 divider, or 200 mv with 80B-5 divider). This control may be adjusted through the access hole on the top of the supply.

4-13. ADJUSTMENT OF OVERLOAD CURRENT

a. Connect a 1K, ±5%, 2W resistor to the output of the 405B.

b. Set the controls on the 405B as follows:

all voltage dials	0
POLARITY switch	- (negative)
HIGH VOLTAGE switch	STANDBY-RESET
POWER switch	ON

c. After STANDBY-RESET lamp illuminates, set the HIGH VOLTAGE switch to HV ON. The STANDBY-RESET lamp will extinguish, and the HV ON lamp will illuminate.

d. Set the power supply for maximum current limit by turning R218 completely counter-clockwise. This control may be adjusted through the access hole on the top of the supply.

e. Set the voltage dials to that output voltage which will deliver 35 ma to the load resistor. For example, 35 volts will deliver approximately 35 ma to a 1 K, 5%, 2W resistor.

f. Slowly turn R218 clockwise until the overload circuit removes power from the high voltage rectifiers.

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. The following list describes all normally replaceable parts of the Model 405B High Voltage DC Power Supply. Parts are identified on the list and on corresponding illustrations by reference designations from the schematic diagram. Those parts (mechanical) which have no reference designation are identified on the illustrations by Fluke stock number.

5-3. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the 405B. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List at the end of this section.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used wherever possible, and can be obtained locally. All parts manufactured or altered by Fluke, and all parts for which Fluke controls the design, are identified by an asterisk preceeding the Fluke stock number. All structural parts and all special parts should be ordered from your local Fluke representative or from the factory.

5-6. When ordering parts always include:
a. Reference designation, description, and Fluke stock number.
b. Instrument model and serial number.

5-7. Most structural parts are not listed. To order these, give complete description, function, and location of part.

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Final Assembly (See Figure 5-1)	*156976	
	Front Panel Assembly (See Figure 5-2)	*156927 (405B-405)	
	Amplifier Assembly (See Figure 5-3)	*156885 (405B-401)	
	High Voltage Filter Assembly (See Figure 5-4)	*156893 (405B-402)	
	Switching Assembly (See Figure 5-5)	*156901 (405B-403)	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
C1, C2	Capacitor, ceramic, 0.001 uf ±20%, 3000V	1501-105635	
C3, C4	Capacitor, ceramic, 0.01 uf -20/+80%, 500V	1501-105668	
CR1, CR2	Diode, Assembly, 6000 PIV, 100 ma Diode, Assembly, 6000 PIV, 50 ma NOTE: If replacement is required for Fluke Stock No. 4801-113423, replace it with Stock No. 4801-169755.	4801-113423 4801-169755	C D
K1	Relay, High Voltage	3150-156968	
R1, R2	Resistor, composition, 470Ω ±1%, 1W	4704-109710	
R3	Resistor, composition, 100Ω ±10%, 1W	4704-109363	
R4, R5	Resistor, composition, 470Ω ±10%, 1/2W	4704-103415	
S3, S4	Switch, interlock, 15A, 230 VAC, SPDT	5104-115196	
S5B	Switch, rotary, 12 positions, 1 section	5108-155986	
T1	Transormer, Power	5602-156992	
V3, V4	Electron tube, pentode, type 8068	*156422 (413C-418)	
	Line Cord, 3-wire	6005-102822	
	Knob, 1-1/2 inch	2405-101311	
	Knob, 1 inch	2405-101287	
	Connector, high voltage	2104-100172	
	Adapter	2113-100222	

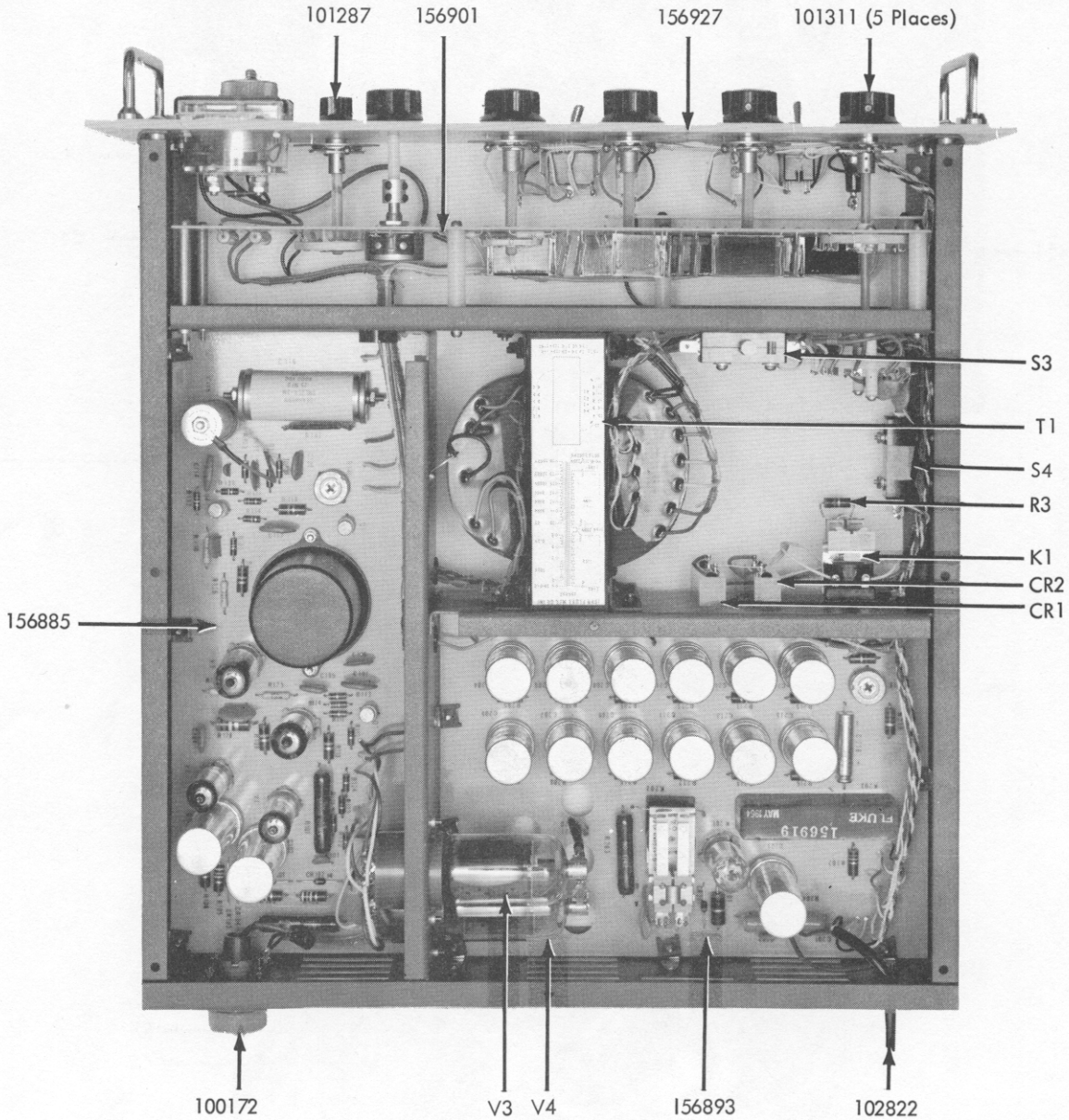
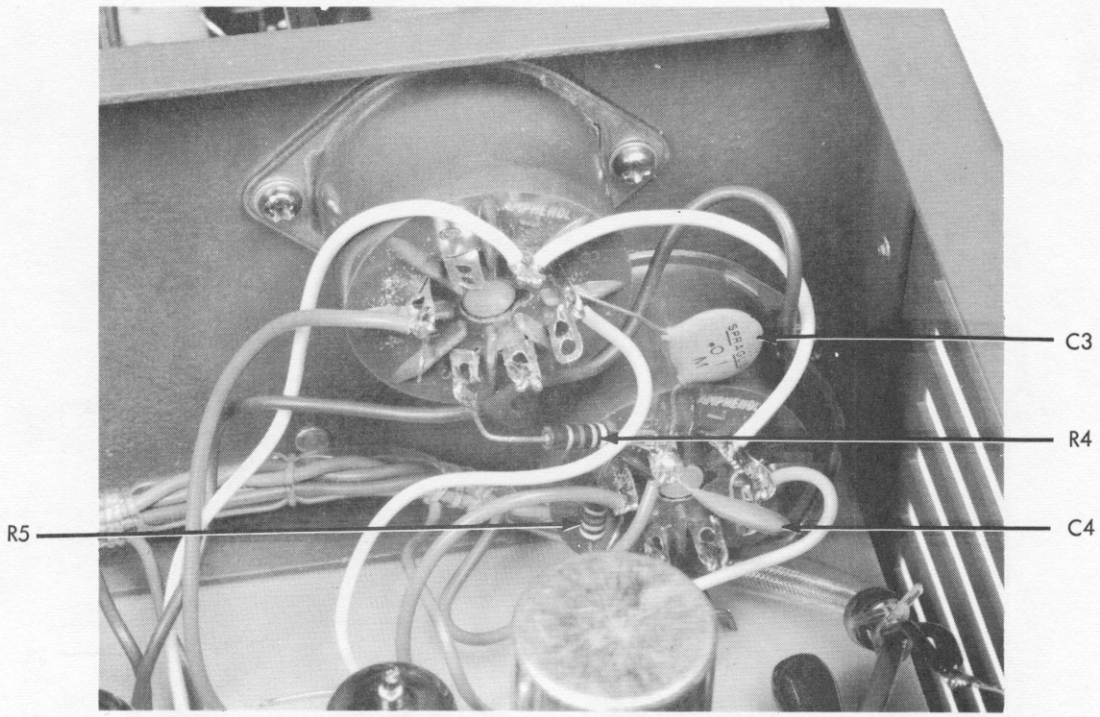


Figure 5-1. FINAL ASSEMBLY (sheet 1 of 2)



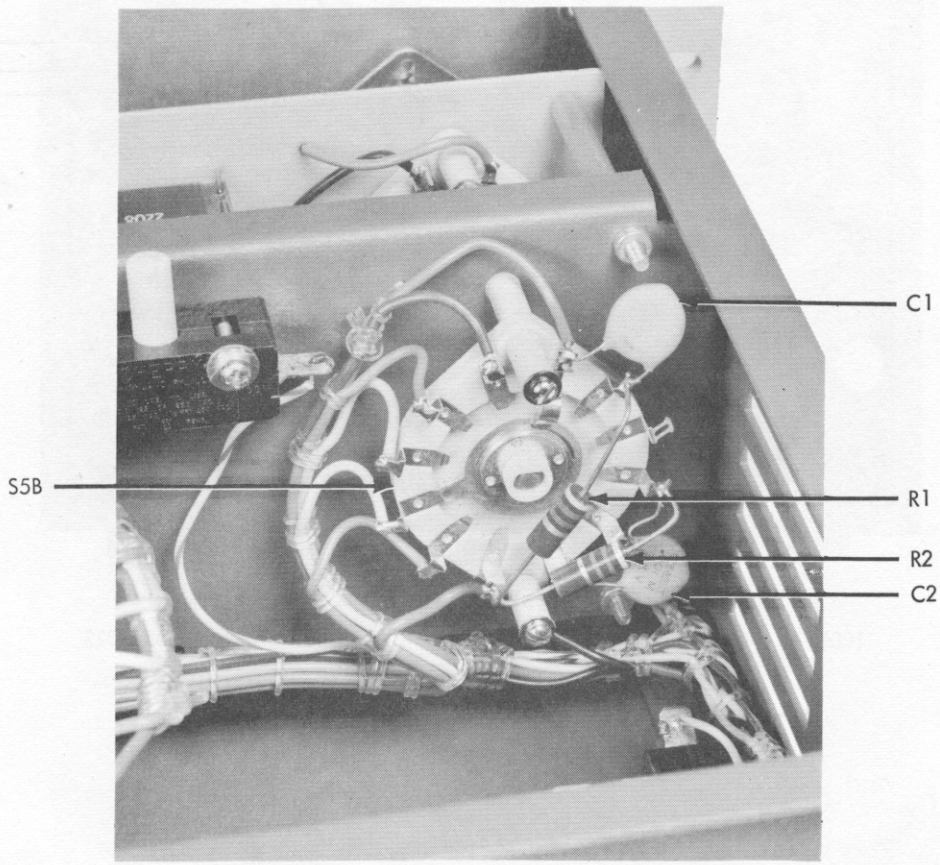


Figure 5-1. FINAL ASSEMBLY (sheet 2 of 2)

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Front Panel Assembly	*156927 (405B-405)	
DS1, DS2	Indicator Light, white neon	3903-100214	
DS3	Indicator Light, red neon	3903-100206	
R6	Resistor, composition, 1.5K ±10%, 1/2W (not illustrated)	4704-108159	
S1	Switch, toggle, DPST, 250V, 8 Amps	5106-114835	
S2	Switch, toggle, DPDT, 250V, 10 Amps	5106-157883	
F1	Fuse, 3A, Slo-blo (not illustrated)	5101-109280	
	Fuseholder	2102-100107	
	Connector, high voltage	2104-100172	
M1	Meter, 500-0-500 ua, ±2%	2901-147033	

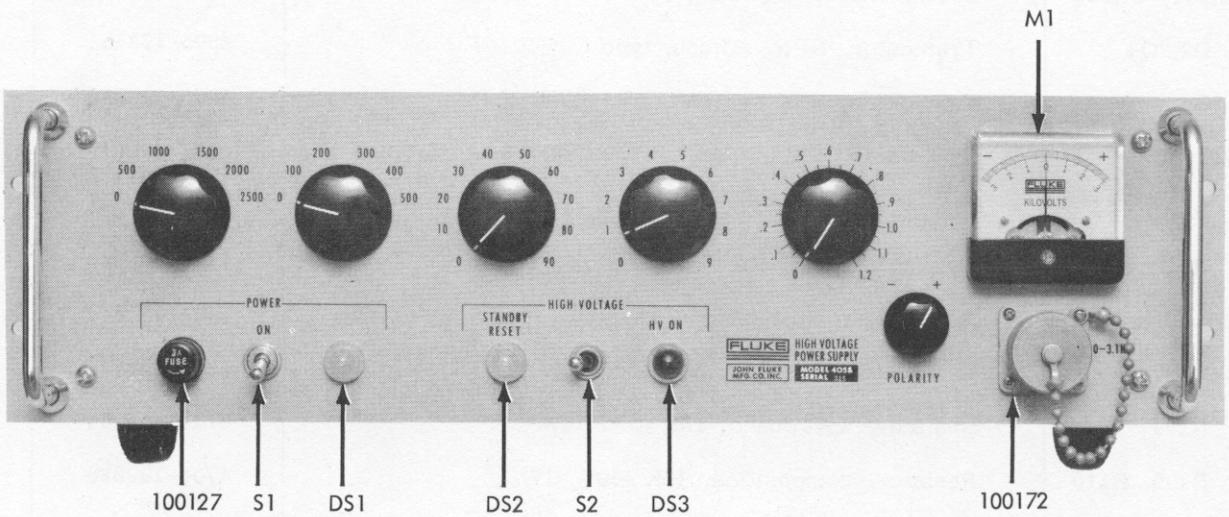


Figure 5-2. FRONT PANEL ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Amplifier Assembly (without tubes)	*156885 (405B-401)	
C101	Capacitor, ceramic, 0.0033 uf ±20%, 1000V	1501-106674	
C102, C103	Capacitor, electrolytic, 40 uf -10/+100%, 500V	1502-106765	
C106	Capacitor, ceramic, 0.0047 uf ±10%, 500V	1501-106724	
C107	Capacitor, ceramic, 0.1 uf -20/+80%, 500V	1501-105684	
C108	Capacitor, ceramic, 0.05 uf -20/+80%, 500V	1501-105676	
C109	Capacitor, ceramic, 0.1 uf -20/+80%, 500V	1501-105684	
C110	Capacitor, ceramic, 0.01 uf, -20/+80%, 500V	1501-105668	
C111	Capacitor, ceramic, 0.0047 uf ±10%, 500V	1501-106724	
C112	Capacitor, ceramic, 180 pf ±10%, 500V	1501-105890	
C113, C114	Capacitor, ceramic, 0.1 uf -20/+80%, 500V	1501-105684	
C115	Capacitor, oil, 0.05 uf ±10%, 4000V	1505-106807	
C116	Capacitor, oil, 0.25 uf ±10%, 3000V	1505-104836	
CR101 thru CR104	Diode, silicon, (CR101 not illustrated), 600 PIV, 0.75A	4802-112383	
CR105, CR106	Diode, zener, 10V, 12.5 ma	4803-113324	
CR107, CR108	Diode, silicon, 600 PIV, o.75A	4802-112383	
Q1, Q2, Q4	Transistor, NPN, silicon, type CDQ10449	4805-153551	
Q3	Transistor, PNP, germaium, type 2N2043	4805-155226	
Q5, Q6	Transistor, NPN, silicon, type CDQ10449, Matched pair	4805-170316	
R101	Resistor, composition, 10 ±10%, 1/2W	4704-108092	
R102	Resistor, composition, 180Ω ±10%, 2W	4704-155457	
R103 thru R106	Resistor, composition, 470K ±10%, 1W	4704-151340	
R107	Resistor, wirewound, 30K ±5%, 10W	4706-155432	
R108	Resistor, wirewound, 15K ±5%, 10W	4706-155424	
R109, R110	Resistor, composition, 10K ±10%, 1W	4704-109380	
R111, R112	Resistor, composition, 1K ±10%, 1/2W	4704-108563	A
R113	Resistor, composition, 2.2K ±10%, 1/2W	4704-108605	B
R114	Resistor, composition, 47K ±10%, 1/2W	4704-108480	
R115	Resistor, composition, 1K ±10%, 1/2W	4704-108563	
R116	Resistor, composition, 15K ±10%, 1W	4704-109421	

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
R117	Resistor, composition, 220 ±10%, 1/2W	4704-108217	
R118	Resistor, metal film, 2K ±1%, 1/2W	4705-151266	
R119	Resistor, metal film, 10K ±1%, 1/2W	4705-151274	
R120	Resistor, temperature sensitive, 10K ±10%, -4.4%/°C	4708-104596	
R121 thru R124	Resistor, composition, 1K ±10%, 1/2W	4704-108563	
R125	Resistor, metal film, 100K ±1%, 1/2W	4705-151316	
R126	Resistor, metal film, 47.5K ±1%, 1/2W	4705-148908	
R127	Resistor, composition, 12K, ±10%, 1W	4704-155465	
R128	Resistor, composition, 180K ±10%, 2W	4704-155440	
R129	Resistor, metal film, 301K ±1%, 1/2W	4705-151282	
R130	Resistor, metal film, 825K, ±1%, 1/2W	4705-151308	
R131	Resistor, composition, 3.3K ±10%, 1/2W	4704-108373	
R132	Resistor, composition, 68K ±10%, 1/2W	4704-108332	
R133	Resistor, composition, 4.7K ±10%, 1/2W	4704-108381	
R134	Resistor, composition, 12K ±10%, 1/2W	4704-108977	
R135	Resistor, composition, 1 M ±10%, 1/2W	4704-108134	
R136	Resistor, composition, 560K ±10%, 1/2W	4704-108795	
R137	Resistor, composition, 180K ±10%, 1/2W	4704-108431	
R138	Resistor, composition, 2.2K ±10%, 1/2W	4704-108605	
R139	Resistor, composition, 1K ±10%, 1/2W	4704-108563	
R140	Resistor, variable, wirewound, 1.5K ±10%, 1-1/4W	4702-156398	
R141	Resistor, wirewound, 2.7Ω ±10%, 2W	*4707-157016	
V1	Electron tube, voltage regulator, type OB2	5701-115899	
V2	Electron tube, voltage regulator, type OA2	5701-115873	
V5	Electron tube, triode-pentode, type 6AU8A	5701-116426	
V6	Electron tube, twin triode, type 12AT7	5701-115923	
V7	Electron tube, voltage reference, type OG3-2	*5701-116749	

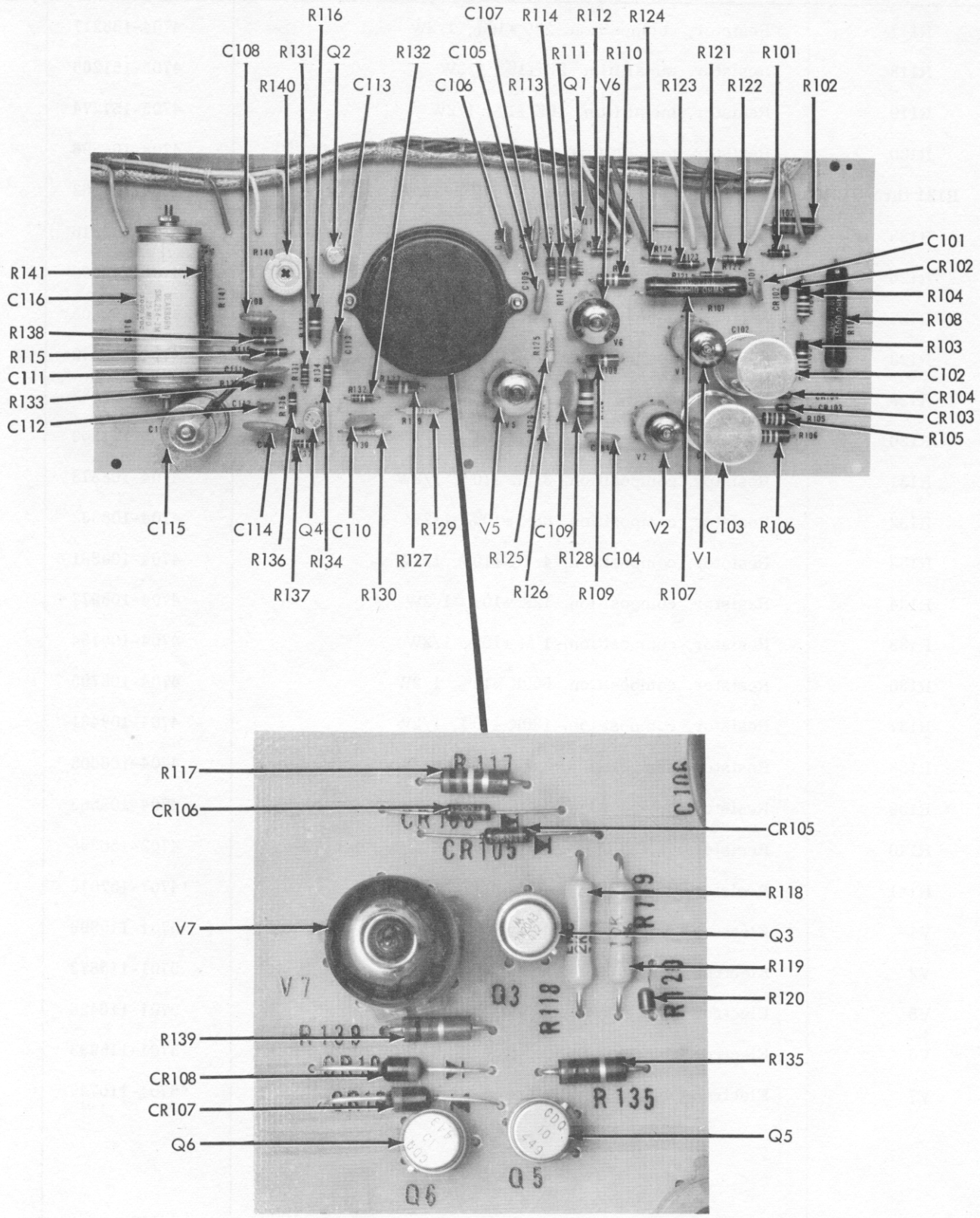


Figure 5-3. AMPLIFIER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	High Voltage Filter Assembly	*156893 (405B-402)	
C201, C202	Capacitor, ceramic, 0.01 uf -20/+80%, 500V	1501-105668	
C203	Capcitor, electrolytic, 40 uf, -10/+100%, 500V	1502-106765	
C204 thru C215	Capacitor, electrolytic, 20 uf -10/+100%, 500V	1502-105932	
C216	Capacitor, electrolytic, 50 uf -10/+75%, 50V	1502-105122	
CR201	Diode, silicon, 600 PIV, 0.75A	4802-112383	
K201	Relay, time-delay, 30 Sec, 115V	4502-105288	
K202	Relay, armature, DPDT	4504-148940	
K203	Switch, reed	3155-156919	
R201	Resistor, composition, 10Ω ±10%, 2W	4704-110163	
R202	Resistor, composition, 68K ±10%, 1W	4704-109629	
R203	Resistor, wirewound, 2K ±5%, 10W	4706-155416	
R204	Resistor, wirewound, 1K ±5%, 10W	4706-157933	
R205 thru R216	Resistor, composition, 330K ±10%, 1W	4704-109546	
R217	Resistor, composition, 22Ω ±10%, 1W	4704-109462	
R218	Resistor, variable, wirewound, 1.5K ±10%, 1-1/4W	4702-156398	
R219	Resistor, composition, 180Ω ±10%, 1W	4704-151357	
R220, R221	Resistor, composition, 470Ω ±10%, 1/2W	4704-103415	

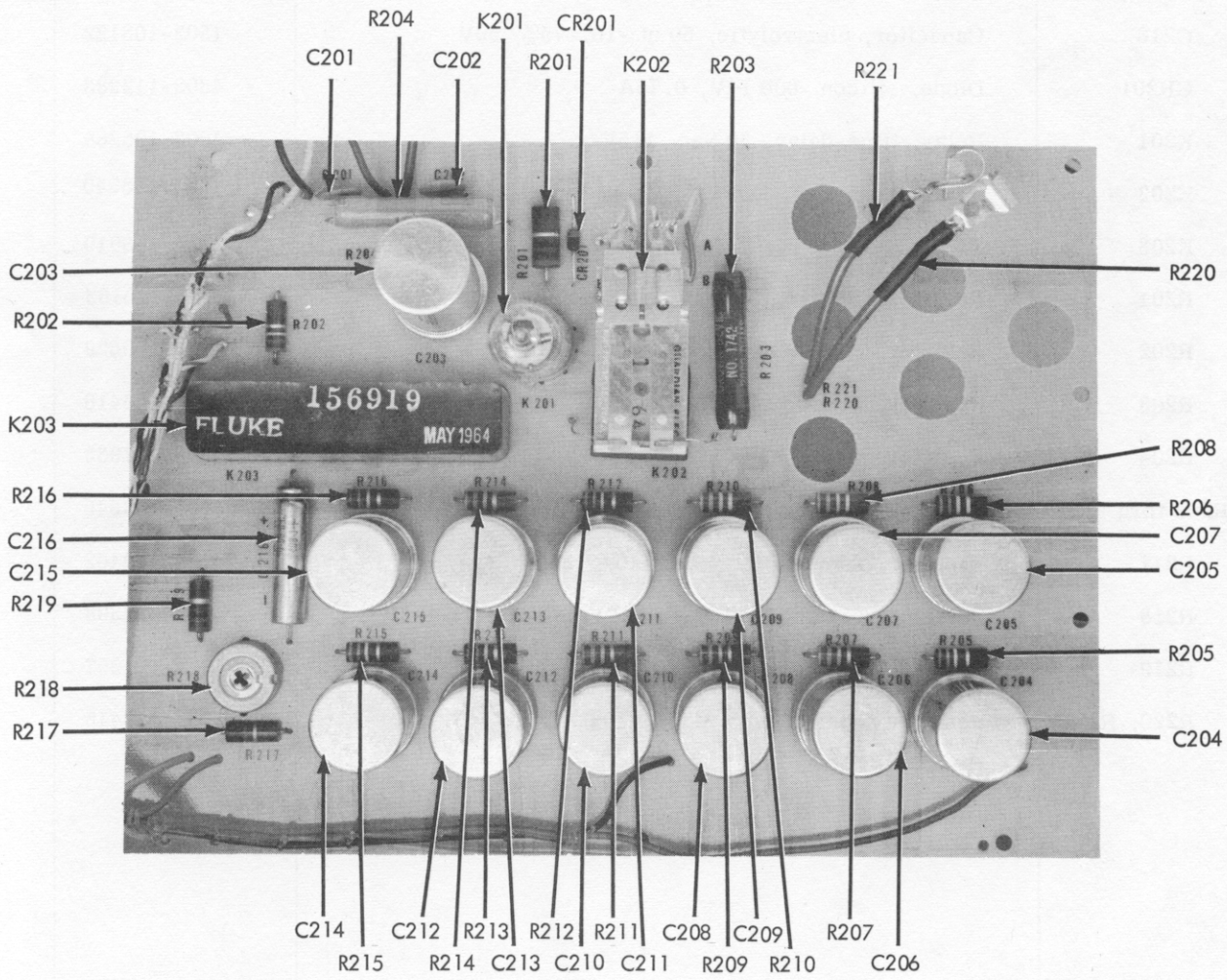


Figure 5-4 HIGH VOLTAGE FILTER ASSEMBLY

REFERENCE DESIGNATION	DESCRIPTION	FLUKE STOCK NO.	USE CODE
	Switching Assembly	*156901 (405B-403)	
R301 thru R305	Resistor, wirewound, 250K ±0.1%, 2W	*4707-156448	
R306, R307	Resistor, wirewound, 100K ±0.1%, 1W	*4707-142349	
R308	Resistor, wirewound, 50K ±0.1%, 1W	*4707-156455	
R309 thru R312	Resistor, wirewound, 10K ±0.1%, 1W	*4707-131664	
R313	Resistor, wirewound, 5K ±0.1%, 1/2W	*4707-149708	
R314 thru R317	Resistor, metal film, 1K ±1%, 1/2W	4705-151324	
R318	Resistor, metal film, 499Ω ±1%, 1/2W	4705-151514	
R319	Resistor, variable, wirewound, 600Ω ±10%, 2W	4702-155523	
R320	Resistor, wirewound, 42K ±0.1%, 1W	*4707-156463	
R321	Resistor, deposited carbon, 1.18M ±10%, 1/2W	4703-107631	
R322	Resistor, deposited carbon, 2.2M ±10%, 1/2W	4703-107227	
R323, R324	Resistor, deposited carbon, 3M ±1%, 2W	4703-155234	
S5A	Switch, rotary, 12 positions, 1 section	5108-155994	
S6 thru S8	Switch, rotary, 10 positions, 1 section	5108-155978	
S9	Switch, rotary, 2 positions, 1 section	5108-155929	

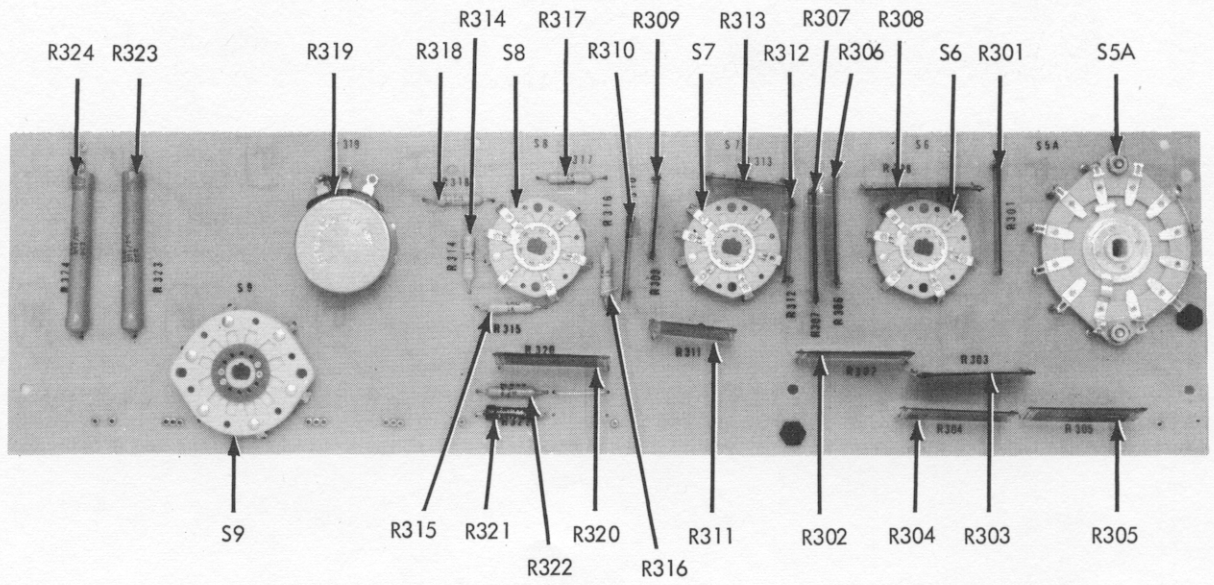


Figure 5-5. SWITCHING ASSEMBLY

5-8. USE CODE EFFECTIVITY

The customer can determine the effectivity of replaceable parts by use of the following use code effectivity list. All parts with no code are used on all instruments with serial numbers 123 and on. New codes will be added as required by instrument changes.

USE CODE	EFFECTIVITY
No Code	Model 405B serial number 123 and on
A	Model 405B serial number 123 through 172
B	Model 405B serial number 173 and on
C	Model 405B serial number 123 through 292
D	Model 405B serial number 293 and on

WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON